CHAPTER ONE

INTRODUCTION

1.1 Introduction

Pattern recognition is considered as part of artificial intelligence specialized in highlighting shapes comparing with custom forms for comparing operations. There are many different types of pattern recognitions, such as face recognition, shape recognition and character recognition[8].

Character recognition plays important role in the modern world. It can solve more complex problems and make human's job easier[9][4]. Character recognition can be divided into handwritten and printed character recognition, handwritten known as writing by hand, and the printed character can be identified by the way of writing using templates .

Handwritten character recognition has been divided into off-line and online character recognition. The offline handwriting recognition refers to the process of recognizing character which is scanned and stored digitally, to be ready for recognition. The online handwritten character recognition, is captured and stored in digital form via different techniques. Such as smart devices, the data generated by writing users with a stylus on an electronic device is known as digital link, and the process of writing is called on-line handwritten[5] [4][8].

Handwritten number recognition has been considered for a long time as a challenging problem facing researchers in this field. The major concern of this research is handwritten Arabic (Indian) numerals[10][8].

By using computer, emphasis should be made on the digit in the handwritten recognition problems facing researchers in this area, which was the great difference between the models entered in terms of size and shape of the same number. It is taken from different handwritten samples and this lead to models being mismatched[11]. This thesis, focuses on the feature extraction stage because it is considered as the initial and most important step in recognition system. If feature extraction gets better, recognition rate will increase[5].

1.2 Problem Statement

Handwritten Arabic (Indian) number recognition is a challenging problem, since Arabic (Indian) numbers have no fixed pattern. A handwritten number compound enough due to differences in shape and size of handwritten numbers produced by different writers, but it has fixed properties and features. Therefore, the proposed approach is to improve the preprocessing stage, and select the features that will enable the identification of numbers with different shapes and sizes, which may enhance the recognition rate.

1.3 Research Objectives:

- To create an Arabic number dataset.
- To propose Arabic number recognition system based on morphology and neural network.
- To evaluate the proposed system based on noise, skewness, on the proposed dataset.
- To study the Arabic (Indian) number characters.

1.4 Thesis Outlines:

This research consists of five chapters organized as follows:

Chapter two(Theoretical Background):this chapter introduces the basic concepts used in the research, contains introduction, and related work.

Chapter three(Proposed Approach):This chapter presents implementation of the proposed approach.

Chapter four(Experiment Result):This chapter describes results, presents recognition accuracy , discusses results ,and displays limitations.

Chapter five(Conclusion and Future work): This chapter shows conclusion and suggestions for future work.

Chapter Two

THEORETICAL BACKGROND

2.1 Related Work

In (2010), Yanping et al. [1] proposed recognizing China-style license plate , The proposed system consists of four stages, license plate location, image pre-processing, character segmentation and character recognition. License plate location: this stage extracts license plate candidate regions from all scenes. The researcher adopted the license plate location method, which is based on color character and vein character. At first, color picture is changed from RGB to Hue Saturation Intensity (HIS), In this stage canny filter is used for processing. Image pre-processing: this stage converts the image to gray type, conversion to the gray was carried out to improve speed processing as the colorfulness lowers the speed of system, in this stage the frame border is removed, morphology closing, dilation and erosion used to remove noises, extract feature and detection edge. Character segmentation: use this stage to improve horizontal projection; this method is effective with Chinese characters unconnected. Character recognition, back propagation neural network is used to recognition of license plate characters. the presence of skew affects the results are negative, for this reason the researcher developed a new algorithm designed to cure the skew through skew correction to get better recognition of license plate. the search to realize no-skew the success detection rate of characters was up to 76%; on skew the success detection rate of characters was up to (73.1%) [1].

In (2010), Kumar, et al.[2] used a new method to recognize the handwritten numbers. The researcher divide the numbers into two groups; first group consists of numbers that contain blobs with/without stems, and contains {0,4,6,8,9}; the second group consists of numbers with only stems {1,2,3,4,5,7}. The first group is divided into two subgroups, one magistrate consists of two blobs and the second consist of one blob. The researcher used the concept of morphological region filling methods because of its advantages in getting rid of the problems result through determine the size of the blob and the main components of the process of discrimination of the number. the objective of this research is to give the elements and links for distinction between numbers to become easier and faster using the benefits of the morphological decision tree. applying this method to various handwritten numbers from modified NIST (National Institute of Standards and Technology) (MNIST) handwritten digit

database .The average success rate of recognition for all digits were above(90%). This method is Inactive in the case of large spaces between the numbers, incomplete numbers and digit with extra stems[2].

In (2007), Fatimah and Husain [3] They proposed a system based on mathematical morphology, The researcher has been complemented by the work of Haralick and Kanungo, where the researcher recognized 6 numbers. this paper intends to improve and develop the previous work which recognizes the remaining 4 numbers as well. in this paper there are 4 digits to be recognized i.e. 0, 1, 7, and 8. This 4 numbers can be divided into two groups: 0 and 8 both can make one circle or two circles without any presence of horizontal or vertical lines. Both the digits 1 and 7 consist of vertical or near vertical lines. the sample of images exceeded one hundred and was collected from a large number of people. The method was tested on the sample set and a substantial recognition rate of more than (80%) [3].

In (2010), Alfonse et al.[4] Presented a new algorithm for segmenting Arabic numerals. In the proposed system , firstly use alpha trimmed filter for noise removal and smoothing. In the second stage, there two problems: 1- Overlapping between characters: this problem is solved by eroding the image starting from the middle left to the right, working with some sequence of black pixels recursively and grouping them as one character segment. 2- Connections between numerals: solved this problem starts from the mid left point to determine whether to go up or down and apply the rules as specified in the proposed algorithm. In feature extraction stage, use Principle Component Analysis technique (PCA). The classification stage is based on two Neural Networks and decision tree. testing of the proposed recognition system indicates that the classification accuracy is within average of (83%) [4].

In (2010), Wang, Yang and Wenzhan [5] Proposed a new feature extraction method based on structural feature for Offline Handwritten Digit Recognition (OHDR), by using the method of human recognition. In this research focus on feature extraction. Firstly state value then in this step feature extraction has to be extracted, secondly determine eigenvalues (A,B,C). The eigenvalue according following steps: step 1: transformed picture in 1 or 0 dimensional square matrix, step 2: The number of the nodes which the boundary line intersects through the curves is calculated as the first eigenvalues, Step 3: Handwritten digit is divided into two parts, upper part and lower part, the boundary is in the middle of the matrix. With this method there is a reduce of possibility of error, speed is quite fast and high recognition is achieved [5].

In (2007), Faisal Tehseen and Kamran Yousaf [6] uses neural networks, starting by collecting a sample handwritings from different people on specific form containing 10 rows to write the numbers of 0 to 9 so that it contains this context. The constant size for all samples then collected and entered into the computer through scanner. In the second phase an image slicing technique was used to slice sample image size into 16*16 pixel, this will give a standard size and resolution of the image , such that it will be able to apply neural network as the identification of the image through this network is directly proportional to the resolution of the image. The third phase comes after training where incorporate samples into neural network and determine the weight and the base of each number and then are classified as final. This process is beneficial in that the introduction of any new image containing the numbers to know it can produce quick results, proven and this method is very fast and more effective than other methods used [6].

In (2009), Al-Omari, et al.[7] The idea of this research collect of images that contain samples of writing . The image will be processed into several phases such as image enhancement, thinning, skeletonaization and segmentation before recognizing the digit. The researcher obtained 10 separate numbers from 10 different writers, and the samples obtained were 1300 in number that were further divided into two parts, 1000 training, 300 testing, finally analysis has shown

a (95%)accuracy. The researcher uses two neural networks to improve on previous results [7].

2.2 Steps of Recognition Process:

Recognition operations generally can be divided into four steps.

- The first step: (Data Acquisition): In this step, images are collected.
- Second step: (Preprocessing) In this step, a set of operations can applied to get a more clear image.
- Third step: (Features Extraction) In this step, the researcher will emphasize on extracting features for each number.
- Fourth step: (Classification). In this step, classification and recognition is made [4][15][9].

2.3 Optical Character Recognition (OCR):

OCR is a technique for entering text into the computer by document readers. At the first step, scanner produces digital image of the text to be recognized. The software programs transform the digital image into codes that can be entered and processed in the computer. Principally, this process requires special character forms, though most current OCR systems recognize Latin characters typed with standardized fonts. Optical character readers are currently used in many applications such as electricity and gas companies so as to insert the data and information collected on counter cards, as well as systems designed to assist human in recognition of handwritten scripts made by investors, and many other similar systems[18][15][19].

2.4 Handwritten Recognition:

Handwritten Is known as the way of writing by using hand, handwritten characters are more difficult to recognize than printed characters because the writer

rewrites the same character differently every time, though not totally different, but the character is written differently. It seems to be hard to write one character the same shape every time it is written. The problem is further complicated if two persons write the same character, so it will be actually difficult for two persons to produce the same form of a character. It is commonly known that different people produce different handwriting. So, recognition of handwriting by computer applications still underdevelopment and needs more research to increase accuracy.

There are many handwriting recognition applications, for example Auto-sorting of mail messages by recognizing addresses and redirecting messages to a destination as meant by the addressee. Another example is check authentication and automated cashing by reading and checking the handwritten amount sum automatically [20][17].

2.5 Online vs. Offline

Handwriting recognition is divided into two categories, online recognition and offline recognition. Online recognition utilizes special device, such as pen, to record on special board during writing at special time of interaction.

In offline recognition, image is captured by digital devices, based on scanned image data, convert image into 1 or 0 pixels [10].

Online recognition of writing takes place during the writing process and characters can be easily recognized than a written sheet. The computer recognizes characters one by one, and the recognized data will be connected into the computer as meaningful information to facilitate character recognition. However, the writing will be with special pen connected to a special panel or pad. For example modern cellular phones allow the capability of direct drawing using human hand on such specially designed screen. But it is difficult to apply that technology at all times, where traditional and commonly known methods used, with no direct writing.

Practically, there is a real need to recognize characters not only from each other, but also to recognize characters by changing them from handwritten into printed characters. For example, where a need arises to authenticate someone's signature, the

recognized characters are turned into digital form, stored into the computer, then the signature will be authenticated as needed simply by matching.

Online recognition is easier than offline because it has more data, and the character is analyzed directly with greater focus on what is written now with minimal confusion.

There are great advantages for the offline recognition of handwriting that implies identification of the handwritten characters in a digital form. This has greater advantage in the communication between human and machine and helps process handwritten text [10].

2.6 Mathematical Morphology (MM):

Greek words mean the study of forms based on geometry and shape and used as tools to extract image features. It is used to describe shapes, and useful in image preprocessing operations . It is also used in biology, linguistics, and geography. It is described as a set of algebra used to process an image, and extract image components Figure (2.1) shows morphology operations[12].

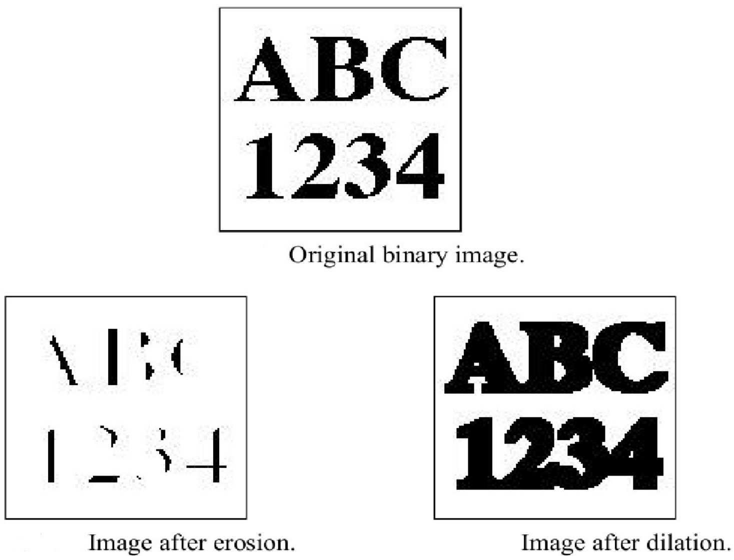


Fig 2.1 Example of morphology operations

The Mathematical Morphology has become widely used, especially in image processing applications because its results are better than other methods in this field. Mathematical morphology can extract image shape features, such as edges, blobs and points, holes, by operating with various shapes and images[12].

2.6.1 Dilation:

Dilation is one of the two basic operators in the mathematical morphology. It is always applied to binary images, The basic effect of the operator on a binary image is to gradually enlarge the boundaries of the regions of foreground pixels .Thus areas of foreground pixels grow in size while holes within those regions become smaller[15][3][12].

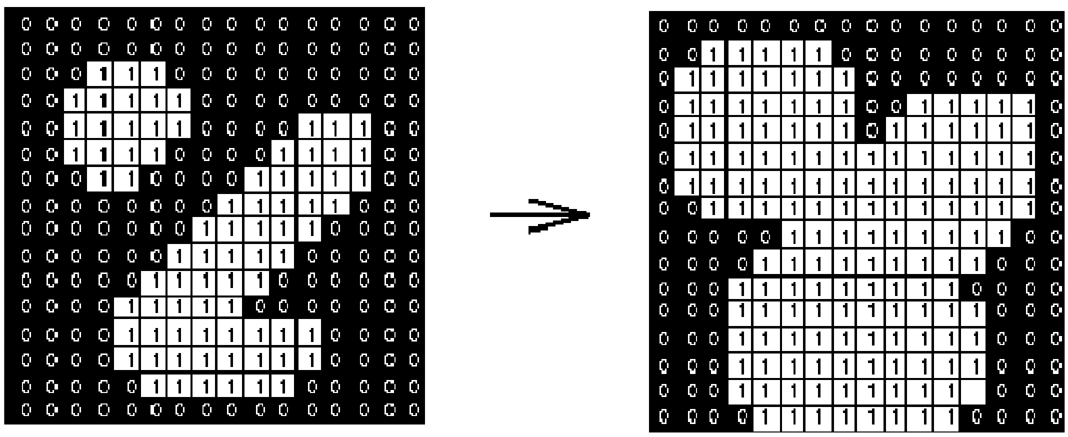


Fig 2.2 Dilation Morphology

2.6.2 Erosion:

Is second famous operator after dilation . The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels . Thus areas of foreground pixels shrink in size, and holes within those areas become larger[15][3].

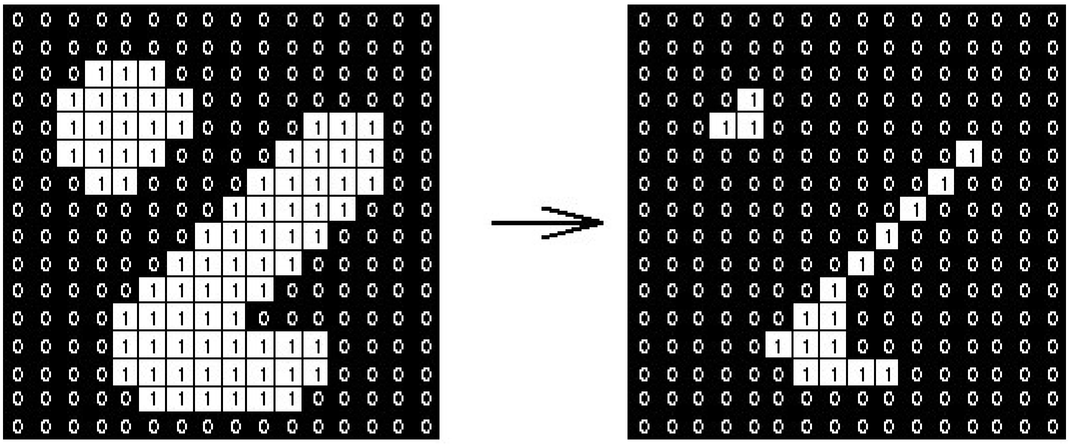


Fig 2.3 Erosion Morphology

2.6.3 Region Filling

The objective of region filling is to fill value 1 into the entire object region. filling is a process that fills a region of interest by interpolating the pixel values from the borders of the region. This process can be used to make objects in an image seem to disappear as they are replaced with values that blend in with the background area[12].

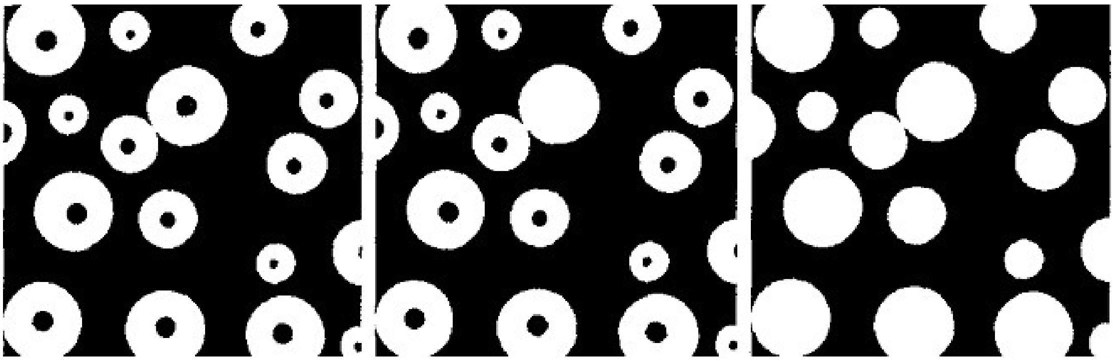


Fig 2.4 Region Fill

2.6.4 Segmentation:

Segmentation used to slicing image into partition to detect the objects in the images, segmentation involves partitioning an image into groups of pixels which are homogeneous with respect to some criterion. Different groups must not intersect each other and adjacent groups must be heterogeneous , The groups are called segments. Figure (2.5) (Left), shows a noisy image containing three objects on a background.

The result of segmentation is given in Figure (2.5)(Right). Four segments were discovered, and are shown with a dashed outline[15][16].

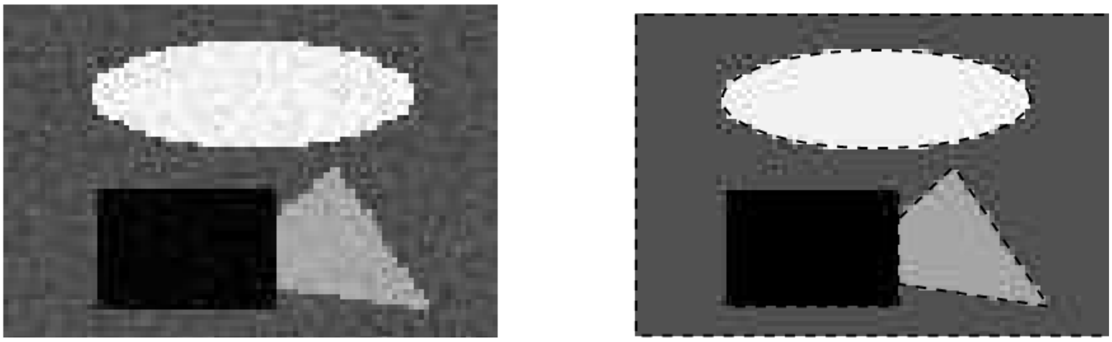


Fig 2.5 Segmentation in morphology(Left: before segmentation, Right: after segmentation)

2.6.5 Components Labeling:

Components labeling scans an image and groups its pixels into components based on pixel connectivity, All pixels in a connected component share similar pixel intensity values and are in some way connected with each other.

Connected component labeling works by scanning an image, pixel-by-pixel (from top to bottom and left to right) in order to identify connected pixel regions, Figure 2.6 shows component labeling example [12].

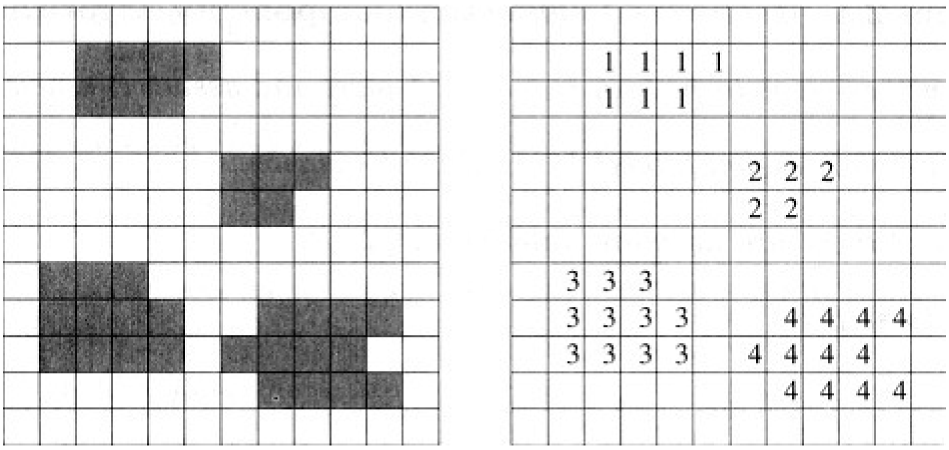


Fig 2.6 Components Labeling

2.7 Binary Image:

Binary images are images whose pixels have only two possible intensity values. They are normally displayed as black and white. Numerically, the two values are often 0 for black, and either for white.

Binary images are often produced by threshold a grayscale or color image in order to separate an object in the image from the background. The color of the object usually white is referred to as the foreground color. The rest usually black is referred to as the background color. They are suitable for printed text or line art because only the values of black and white are needed for these types of images.

Binary images are used in many applications since they are the simplest to process, but they are such an impoverished representation of the image information that their use is not always possible. Binary images are also called bi-level or two-level. This means that each pixel is stored as a single bit (0 or 1), [15][14].

2.8 Feature Extraction:

Feature extraction is the process of extracting useful information from an image to pass them to the classifier. It transforms an image of containing redundant data into a reduced representation set of features. In feature extraction stage each character is represented as a feature vector, which becomes its identity. The major goal of feature extraction is to extract a set of features, which maximizes the recognition rate with the least amount of elements.

Feature extraction can be divided into tow categorise; 1-structural features these techniques based on geometry shapes ,for example endpoints and loops, 2-statistical features which describe a character image by extracting many characteristic criterion from the character image [12][5].

2.9 Neural Networks (Back propagation):

An artificial neural networks (ANN) is an interconnected group of artificial neurons that uses a computational model for information processing based on a connectionist approach. ANN is widely used in many fields of engineering, in particular for pattern recognition, classification and prediction, Figure 2.7 shows architecture of neural network [21].

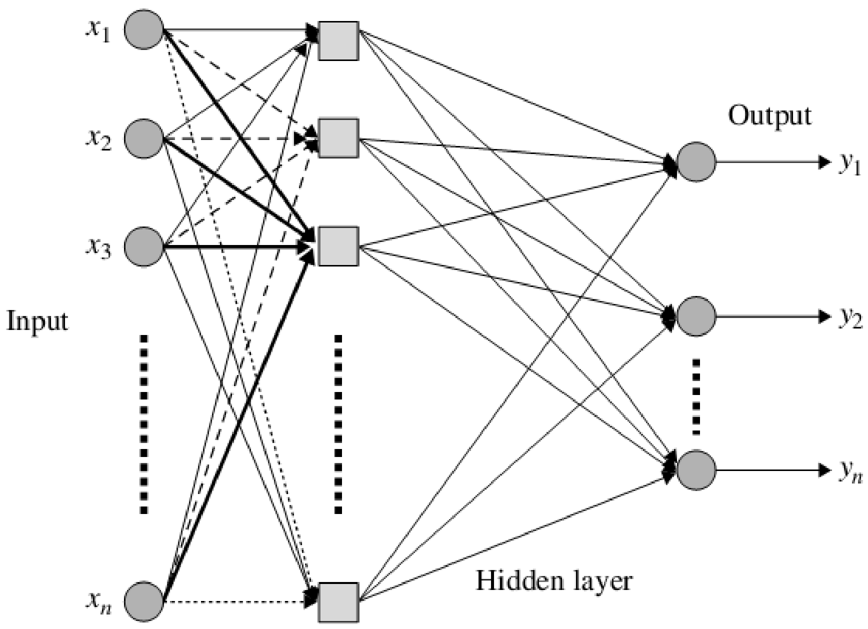


Fig 2.7 Architecture of a layered neural network[15].

Each neural network has been trained using reverse deployment algorithm called the back propagation neural network. The neural network with a back propagation familiar model in neural networks. It is most commonly used in neural networks architecture and the main reason for this is: it is easy to implement, Since the networks used back propagation algorithm to learn complex multidimensional charts more easily than use of other algorithms. and many applications can be formulated using back propagation network where have a model for most of multilayer neural networks. The most common training method use in multilayer neural networks are spreading algorithm back propagation which has been successfully tested for different types of tasks [22][13].

Back propagation algorithm consist of two phases .First phase Is the forward phase. this is the phase where the activations propagate from the input layer to the output layer .The second phase is the back phase. this is the phase where the error the observed, actual and the requested nominal value in the output layer are propagated backwards so it can modify the weights and bias value [22][15].

CHAPTER THREE

PROPSED APPROACH

3.1 Introduction

This chapter discusses the proposed approach to deal with the problem of handwritten, where there is difference in shapes and sizes. This approach will be explained in phases; i.e., preprocessing (using morphology operations), how to extract the features of number from input image according to proposed method and describe the classification and recognition stage.

In this section, the researcher discusses the mechanism of the proposed system, through building a system that is able to recognize handwritten numbers using Neural Network and Mathematical Morphology. The researcher adopted Neural Networks and Mathematical Morphology based on a set of properties for each of them separately, since Neural Networks is used in recognition and classification processes. Morphology was widely used recently in classifying shapes and images.

Merging between Neural Networks and Mathematical Morphology was proposed by Yanping [2], but the proposed system was applied on license plates, since such plates are printed. In this thesis, will merge between Neural Networks and Mathematical Morphology to recognize the Arabic(India) handwritten numbers. This will be applied in a MATLAB environment.

3.2 The Proposed Approach

The proposed approach consist of five primary phases:

1- Scanning: an image has been taken and saved in computer by scanner, then entered to system.

2- Preprocessing: to produce a clearer image, since the most image is clear the better the system can recognize, in this phase, some of the morphological processes are applied in order for the system to recognize, even if it was not clear enough

3- Segmentation: the image of a set of numbers is divided into isolated numbers to facilitate extracting the features of each number.

4- Feature extraction: is the process of extracting useful information from the processed image.

5- Classification: includes entering the new features to the trained network to complete the recognition process. Figure (3.1) shows the proposed system phases.

3.3 Proposed Diagram

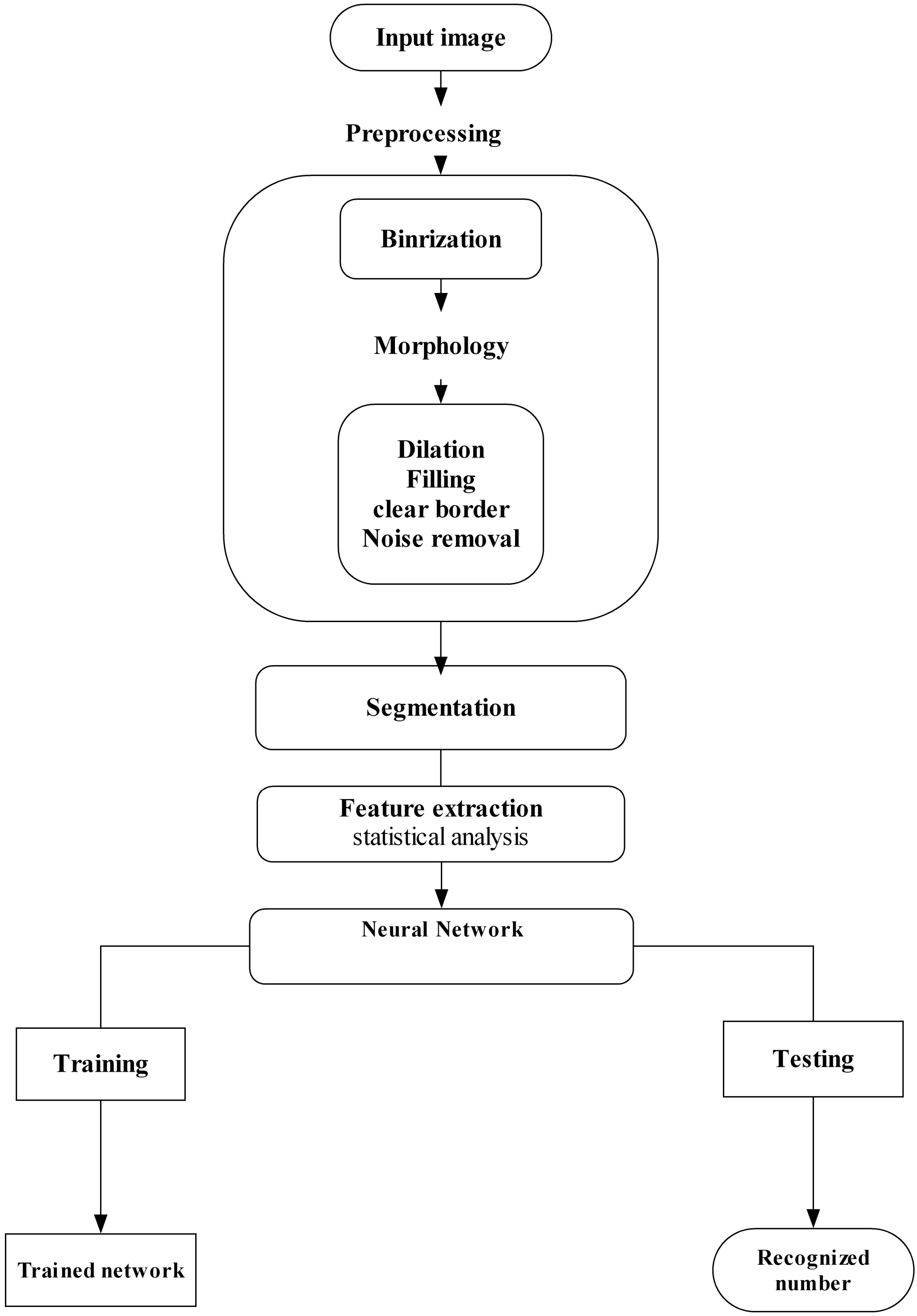


Fig 3.1 Proposed Diagram

3. 4 Scanning and partition :

The proposed system can deal with a set of (numbers) as shows in Fig(3.2), or deal with a sub of set number as shows in Fig(3.3).

- Scanning :get the image , this is done by introducing samples that collected through the scanner into the computer. Fig 3.2 show one sample.

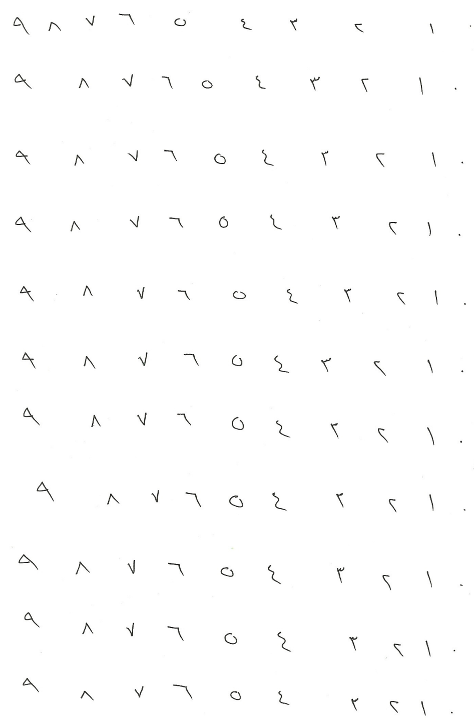


Fig 3.2 Sample of numbers

- Image partition :

This step is in the division of the original image to the rows so that they are ready to enter the system because the original image contains more than one row and more than one column where each row represents a set of numbers that we want to recognize.



Fig 3.3 Row of Numbers

3.5 Grayscale Transformation:

By converting RGB image to grayscale, the image will be easier to deal with by the system, since the grayscale image reserves less space in storage and becomes ready to apply the morphology operations. This transformation is usually expected to

enhance the image contrast, so the details of an image can be clearer. In this research gray transformation implies in Binarization, so have ability to converts the input image to grayscale format (if it is not already an intensity image).

3.6 Binarization:

Convert grayscale image to binary by threshold. Binary images are often produced by threshold a grayscale or color image. Binarization is a method to reduce color image into two colors, black and white. Black and white images only require a single bit per pixel. Logically, this greatly reduces the complexity of the image. Matlab is used to read the image and convert it to black and white type. Figure (3.2) shows Binarization.



Fig 3.4 Binarazation

3.7 Morphology Preprocessing operations:

Morphology is a technique of image processing based on shapes. İn this step, the researcher will apply a set of morphology operations to clear the image in preparation for the next step, which is feature extraction. These operations will be discussed in the following sub-sections.

3.7.1 Dilation

The significance of 'dilation' is to setoff and fill the discontinuous line. Figure(3.5) shows the dilation importance.

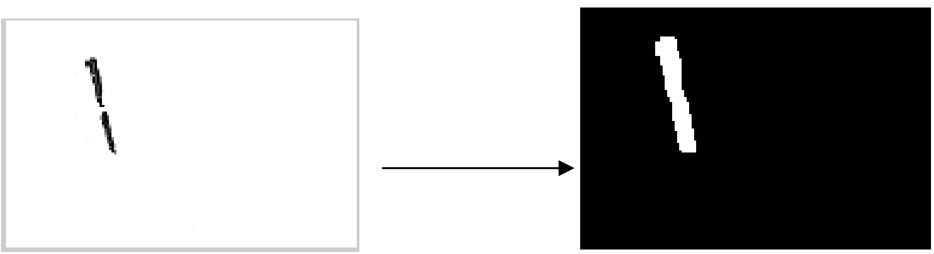


Fig 3.5 Apply Dilation on image

The basic effect of the operator on a binary image is to gradually enlarge the boundaries of regions of foreground pixels. So, this operation can be used to fill empty pixel to a better image. Figure(3.6) shows dilation operation in this system.



Fig 3.6 Dilation

3.7.2 Structure Element:

All morphology operations take two pieces of data as input. One is the input image, and the other is the structure element. This determines the precise details of the effect of the operator on the image.

Structure element, is a shape used to probe or interact with a given image, with the purpose of drawing conclusions on how this shape fits or misses the shapes in the image. In this research use (line) function in two deferent angle, with length 5, which mean object containing 5 neighbors, this function creates a flat linear structure element that is symmetric with respect to the neighborhood center. This function specifies the angle (in degrees) of the line as measured in a counterclockwise direction from the horizontal axis, and have approximately the distance between the centers of the structuring element members at opposite ends of the line.

3.7.3 Filling

This process contributes in increasing some numbers components, making them easily recognized. The mostly critical cases by this process are the numbers (٥ & ٩) as shown in the Fig.(3.7), designated pixel changes connected background pixels (0's) to foreground pixels (1's), stopping only when a boundary is reached.

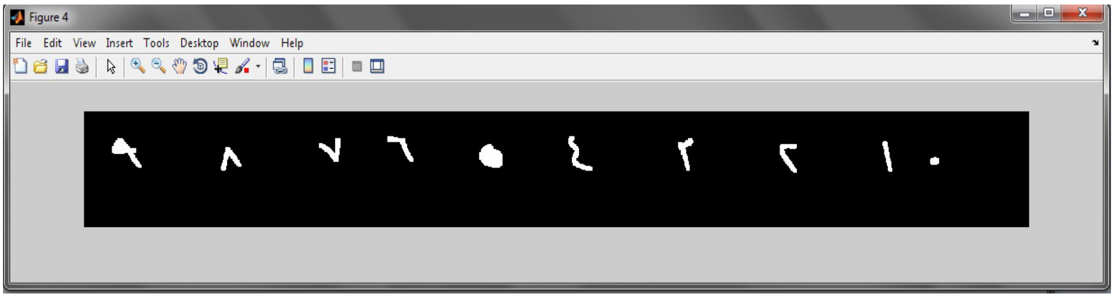


Fig 3.7 Apply Fill Holes on the System

3.7.4 Labeling

In this step, the pixel, in the photo, holding the value of one is divided into groups linked together, where the system conducts a comprehensive scan for the photo. Then, each pixel linked group is divided into a new group with the same number. The process is applied on all the groups to get sub-groups linked together.

3.7.5 Noise Removal

In this research, a determined threshold is used and identified through experimentation to compare with the image component, any shape smaller than these thresholds are considered as noise and removed, while any shape larger than the thresholds are treated as part of the original image and attempt to recognize.

3.7.6 Clear Border

In this stage connected objects on border are removed, any objects that are connected to the border of the image can be removed using the Matlab functions. The connectivity in this functions was set to remove diagonal connections and removes all connected components of a binary image that touch any image border.

3.8 Segmentation:

In this stage, image is segmented into isolated digits, using horizontal projection, each digit is segmented into 4 parts. The system extracts the recognized feature for each digit using feature extraction which is already determined. After that, it is compared with an already saved pattern to complete the recognition operation.

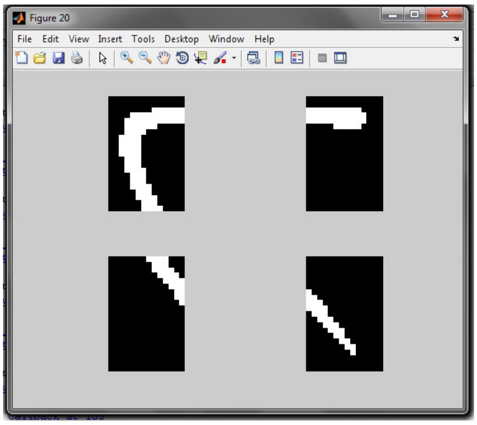


Fig 3.8 Segmentation of number 2

3.9 Feature Selection and Extraction

Feature extraction is the process of extracting useful information from the processed image. It is important to be able to extract features, describe shape and recognize pattern such as size and shape.

This stage is the most important one in the recognition process, using a set of features that helps in the recognition process. These features have been tested in this system, giving high recognition results, the image is divided into 4 segment as shown in figure (3.8) The, 4 statistical features will be calculated for each segment resulting of 16 feature for each image. These features are:

1- Summation of white pixels :

In this step, the divided photo of black and white colors is treated, where the white pixels in each part of the photo are grouped making four sub-groups, representing the total white pixels in the photo. Then, these four sub-groups are stored in an array for the next step.

2- Ratio of white pixel to black pixels :

In this step, the percentage of white pixels in the four sub-groups are calculated and compared with the black pixels in the same photo. This is done through deducting the total number of white pixels from one, which results in the number of black pixels. The percentage of white pixels to black pixels gives a ready value for the next step.

3- Variance :

The variance is used since it is adaptable with the photo regardless of its size. The equation (1) illustrates variance calculation process:

$$Variance = \sum \frac{(x - \bar{x})^2}{n} \quad \text{......................(1)}$$

4- Standard deviation

The standard deviation was also used since it is adaptable with photos of different sizes. The next equation(2) illustrates standard deviation calculation process:

$$S = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \bar{X})^2}{n-1}} = \sqrt{\frac{\Sigma(X - \bar{X})^2}{n-1}} = \sqrt{\frac{\Sigma X_i^2}{n-1}} \quad \text{.....................(2)}$$

The above four features have been used since they are considered as statistical properties, and have the ability to adapt with various image sizes.

These features are dealt with on the basis of the values produced by processing each of them. Then, these values are stored in an array and entered into the network to be compared with the already stored features.

3.10 Neural network:

In this thesis, Neural Networks was used in two phases, training and running. The training phase includes a set of three samples collected from three writers and entered into the network for feature extraction of each number. This results in a

trained network. In the running phase, a set of images of numbers are entered to the system for processing then extract the features of each number. Then, feature extractions are stored in an array and entered into the network and conduct comparison between the trained samples and the new ones.

In this thesis, architecture of the a NN in three layers, first input layer, contains 50 node, second hidden layer, contains 30 node, and third output layer contain 10 node, First two layer, use logarithmic sigmoid transfer function, transfer functions calculate a layer's output from its net input, the log-sigmoid transfer function is commonly used in multilayer networks that are trained using the back propagation algorithm, last layer(output) 10 node, because the system deal with 10 numbers.

3.10.1 Training

Neural network simulate to human brain, because it can deal with new inputs on the basis of previous experiences, this is called learning so it can deal with various applications especially recognition, since there are new inputs every time.

Learning is done by giving the network a set of samples called pattern or training set to extract determined features, after this operation the network will be ready to receive new samples to recognize, based on testing set**.** In this stage, the network is trained on new inputs, to gain (construction) able to recognize the new image.

Trained supervised network in this system was on a set of samples, introduced to the network to extract the mentioned features in this chapter, after obtaining the features stored as a values, incorporate into a array, in the training phase the network will be retained previous values, more than once and aim to get the highest possible value of the input values, then we used ready function to gives value preliminary weight and base. Noise was introduced on the network to be able to deal with images that contain noise. The performance function used in this system SSE.

CHAPTER FOUR

EXPERIMENTAL RESULT

4.1 Introduction:

This chapter will discuss the experimental results achieved by applying the proposed technique. This chapter will also illustrate the methods used to obtain the result.

After reviewing previous researches, the researcher found that the comparison operation varies from one researcher to another and concluded to that there are no fixed standards for comparison recognition. For example, Kumar uses Modify National Institute of Standards and Technology (MNIST) dataset to perform comparison. On the other hand, Alfones used ready patterns to get the required results. But many other researchers concerned with handwritten number, especially Arabic (Indian) numbers, collected samples of numbers from participants. These participants are asked to write on certain samples. some of these samples were collected and subjected to several processes called patterns, while other samples were used for comparison with these patterns.

In this thesis, the researcher will adopt the collected samples from participants, then divide them into two groups. The first one will be used as pattern, while the second one will be used as a test sample.

The proposed approach is implemented in MATLAB environment.

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4.2 Data Sets and Data Collection:

In this thesis, the researcher used dataset collected from 13 participants, every participant was asked to write numbers from (٠) to (٩), ten times.

Each sample has 10 rows and 10 columns, after receiving the samples from the participants they were divided into two groups. The first group contained 30 samples of each number and used as a pattern for training the neural network. The second group contained 100 samples of each number and used for testing.

The aim of the comparison is to check if the program can be applied to other samples or rather to practical life. The dataset will be used to assess performance of the proposed method.

4.3 Cases dealt with by the system

4.3.1 Skew:

In a previous study by Yanping[2], skew affect the accuracy of the recognition process. In this thesis, skew will have no effect, since it depends on horizontal projection, this method is effective with Arabic (Indian) numbers unconnected. Figure 4.1 shows skew example.

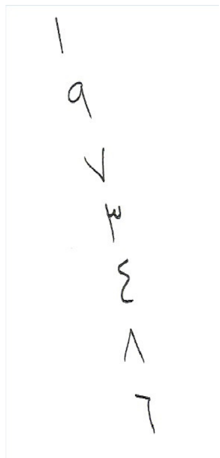


Fig 4.1 Skew Example

In this thesis, the image is scanned and recognition is based on the linked pixels in the image.

4.3.2 noise:

This system deals with "noise" and the results were acceptable through determining thresholds. If the number is smaller than the threshold, it will be eliminated, if the number is greater than the threshold, then the numbers will be presented.

This chapter will explain threshold effect in the recognition process.

4.4 Recognition accuracy:

This section will discuss the result obtained from applying method to recognize Arabic (Indian) handwritten number.

4.4.1 Experimental result 1:

After testing samples on the system recognition, results were different. Table (4.1) shows the results obtained.

In first experiment, the researcher used 130 handwritten of dataset collected from participants. The recognition of success rate of each digit is shown in Table (4.1)

Table 4.1 Result of Recognizing before reducing threshold

Numerals	Number of patterns	Correctly recognized patterns	error
٠	100	41	59
١	100	70	30
٢	100	76	24
٣	100	73	27
٤	100	82	18
٥	100	64	36
٦	100	86	14
٧	100	60	40
٨	100	75	25
٩	100	53	47

At this stage, recognition in average cases was (68%), while the least recognition rate was (٠), because the zero result was affected by threshold, where threshold was (150 pixel), since it is larger than the actual number in the image. The system could not identify the zero and considered it as a noise, but after reducing the threshold, results improved.

4.4.2 Experimental result 2: After reducing the threshold to (70 pixel), the (٠) became recognizable and results have improved by (4.5%). Therefore, the average result became (%72.5) and the following table shows the achieved results.

Table 4.2 Result of recognizing after reducing threshold

Numerals	Number of patterns	Correctly recognized patterns	error
٠	100	86	14
١	100	70	30
٢	100	76	24
٣	100	73	27
٤	100	82	18
٥	100	64	36
٦	100	86	14
٧	100	60	40
٨	100	75	25
٩	100	53	47

Using Neural Networks system back propagation learning, to recognize handwritten digits was successful . An image which contained many 100 numbers of each number, was trained and tested. The accuracy rate of recognizing the number was (72.5%)

After completion of features' extraction of each number, they are inserted to NN, where NN inserts the features into a three layers to perform the required recognition. Accordingly, NN makes the decision of recognition based on what has been trained. When existing patterns are compared with the inserted data, NN recognizes the nearest corresponding numbers to the goal.

4.5 Performance of training :

After specifying all the parameters at NN, Train network is clicked. This gives a training and performance plot.

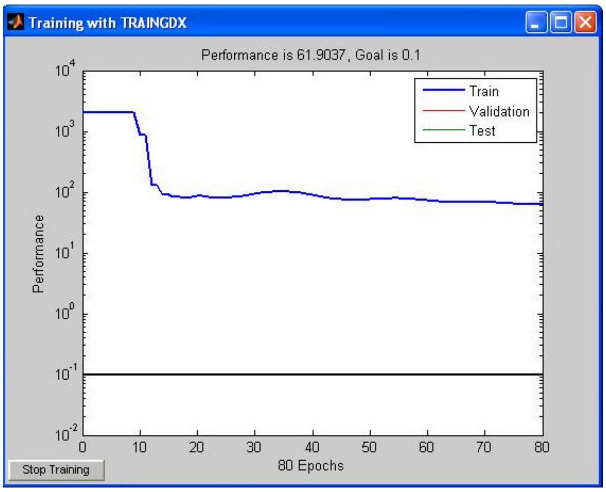


Fig 4.2 Performance of training

Fig.4.2 shows part of the training process of the network, where they are to stop the training process if there is one of the following conditions:

1- Epoch: a specific number of times for the implementation of the training process

2- Goal: if the goal has been reached.

3- Momentum coefficient: is to stop at the sudden change on the progress of the training

4.6 Complexity

Complexity in this system was calculated based on the time lapse of execution. The researcher calculated the complexity as of application time for more than 10 times, calculated the average time of those tests and the result was approximately 7 seconds. In this research, the processor used for the evaluate of the proposed system is Pentium (R) Dual Core, 2.20 GHz with 2 Gigabyte DDRAM. The operating system used is Window seven Ultimate, version 6.1. The system are executed and compiled using Matlab R2008a programming language.

4.7 Result

This section will present results of applying the system. It is noted, as shown in the figure (4.3), that the results are shown in columns and rows, where each column represents a set of numbers with probabilities of recognition, i.e., probability of 9 to be 1 is 0.1913. Each column starts with 1 to 9 then 0.

It is noticed that the percentage of recognition for each number is, to some extent, low, since the tested samples differ than the trained samples in offline.

```
R =

    0.1913    0.0176    0.0709   -0.0038    0.1675   -0.1323    0.0224   -0.0509    1.0705   -0.0143
    0.0991   -0.1501    0.0340    0.0455    0.1937   -0.1188    0.3501    0.9058   -0.1583   -0.0421
   -0.0207    0.1453   -0.0377   -0.0445   -0.1315    0.3498    0.6493   -0.0328   -0.2225   -0.0436
    0.2102    0.1129    0.1190   -0.1008    0.0727    0.5320    0.1259   -0.0078   -0.0220   -0.0606
   -0.2080    0.0510   -0.1761    0.0161    0.7855    0.0687   -0.0230   -0.0769    0.0854   -0.0929
    0.0012   -0.2539    0.0716    0.8217   -0.2478   -0.0067   -0.1385    0.0169    0.0168    0.0895
    0.0089    0.0938    0.7603    0.0331    0.0605    0.1813   -0.1082    0.1181    0.0893    0.1576
   -0.0133    0.8490    0.2062   -0.0416   -0.2163   -0.1017    0.1890   -0.0347    0.0166    0.0405
    0.6512    0.1301   -0.1285    0.3309    0.3326    0.0985   -0.0280    0.1580    0.0594   -0.0398
    0.1504    0.0026    0.0989   -0.0723   -0.0907    0.0651    0.0438   -0.0310   -0.0179    0.9809

Result =

     9     8     7     6     5     4     3     2     1     0
```

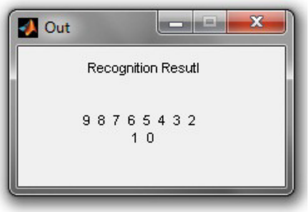


Fig 4.3 Result

After conducting this research, it became obvious that there is a set of main factors that affect the process of recognition:

- The pen used for writing. A pen with a large head had negative results. For example, when the system is applied on a set of images, there were many groups of numbers that couldn't be recognized by the system as a result of interference.

- The Clarity of the image. When the image is clear, the results are better, that is because the processes are easy to be applied, and vice versa is true when the image is hidden and overlapping, the results are worse.

4.8 limitations:

- One of the most problems faced in applying Matlab is that it does not support Arabic (Indian) numbers therefore, outcomes were in English.

- The number (٢), has two different forms in Arabic (Indian) numerals, in this thesis, the researcher attempted to identify both forms, but the results were not valid. When adding the number (٢) both forms, results were completely different as a result of the conflict in identifying the number (٢) and number (٣).



Fig 4.4 Number 2 which has 2 shapes

- The number Zero (٠) is one of the problems which should be solved by using thresholds since the system eliminates the zero in some images holding values less than the threshold. Some problems occurred because there are no certain rules, conditions or size for writing numbers. Some researches attempted to deal with the problem of a number because each participant had his own style in writing. Thus, the researcher minimized the thresholds to a certain limit, which allowed the user to get satisfactory results.

CHAPTER FIVE

Conclusion and Future Works

5.1 Conclusion

This thesis focused on handwritten numbers. This research combined a set of tools in the field of recognition, such as the NN and MM using MATLAB, introducing an efficient and very fast way to solve the problem of the difference in the shape and size of the symbols, where there are no application of handwriting letters and numbers rules.

The main contribution of this thesis is to find a method to recognize the numbers of any size, by selecting a group of characteristics that can adapt to different images, without determining specific size or form for recognition.

Through analyzing the experimental results, recognition rate was (72.5%). After results analyses, the researcher argues that the proposed approach is robust. Yet there are still some images failed to be detected in the experiment, which will be improved in the performance of the algorithm through increasing selected features as will show in the future work.

Expected advantages for this research:

- The possibility of dealing with images that contain a large number of digits
- The possibility of recognition images that contain Noise and skew
- This system scalable to develop and additive easily at any time

5.2 Future works:

There are some suggestions may be introduced to be utilized in future studies which are summarized in the following:

- A viability of increased rates of recognition by focusing on the featured characteristics of each number.
- The ability to add some related properties of writer, this is a subject under study, by researchers.
- Apply the suggestion of the proposed method to recognize the handwritten character.
- Add number 2 in two different forms to the recognition process
- Ability to add rotated numbers.
- Add adaptability of neural network.

References :

[1] Yanping Bai, ,Hongping Hu, Fei Li, Wei Shuang, Lixia Gong "**A Recognition System of China-style License Plates Based on Mathematical Morphology and Neural Network**", International Journal of Mathematical Models and Methods in Applied Sciences, Vol.4, p.p 66 – 73, [2010].

[2] Vijaya Kumar, Srikrishna, Raveendra Babu and Radhika Mani "**Classification and recognition of handwritten digits by using mathematical morphology**", Indian Academy of Sciences, Vol. 35, Part 4, pp. 419–426, [2010].

[3] Fatimah Mohammad and ,S.A. Husain" **Character Recognition Using Mathematical Morphology**", International Islamic University, Islamabad, Pakistan, IEEE**,** [2007**].**

[4] Marco Alfonse, Mohamed Almorsy, Mohamed Samir Barakat ,"**Eastern Arabic Handwritten Numerals Recognition**" International Journal of Computer and Electrical Engineering, Vol. 2, No 2, 1793-8163, [2010].

[5] Wang Qinghui ,, Yang Aiping, and Dai Wenzhan **" An Improved Feature Extraction Method for Individual Offline Handwritten Digit Recognition "**, Proceedings of the 8th World Congress on Intelligent Control and Automation , Jinan, China,978-1-4244-6712-9/10 © IEEE July 6-9, [2010].

[6] Faisal Tehseen Shah, Kamran Yousaf," **Handwritten Digit Recognition Using Image Processing and Neural Networks**", Proceedings of the World Congress on Engineering, London, U.K Vol I WCE, ISBN:978-988-98671-5-7, July 2 - 4, [2007].

[7] Saleh Ali K. Al-Omari, Putra Sumari, Sadik A. Al-Taweel and Anas J.A. Husain "**Digital Recognition using Neural Network**", Science Publications, Journal of Computer Science 5 (6): 427-434, ISSN 1549-3636 [2009].

[8] Jagadeesh Kannan and Prabhakar,"**A Comparative Study of Optical Character Recognition for Tamil Script**", European Journal of Scientific Research, Vol.35 No.4, pp.570-582, [2009].

[9] XU YE and ZHANG Wei ,"**On a Clustering Method for Handwritten Digit Recognition**", Third International Conference on Intelligent Networks and Intelligent Systems, DOI 10.1109/ICINIS.2010.130, IEEE, [2010].

[10] Rejean Plamondon and S. N. Srihari, "**On-line and off-line handwritten recognition: a comprehensive survey**", IEEE Transactions on Pattern Analysis and Machine Intelligence. VOL. 22, NO. 1, IEEE [2000].

[11] Habib Mir Mohammad Hosseini and Abdesselam Bouzerdoum,"**A Combined Method For Persian And Arabic Handwritten Digit Recognition**", Proc. 1996 Australian New Zealand Conf. on Intelligent Information Systems, 18-20, Adelaide, Australia. Editors, Narasimhan and Jain [1996].

[12] Frank y.shih "**Image Processing and Mathematical Morphology Fundamental and Application ",** CRC press, Taylor & Fracis group, 6000 Broken Sound Parkway NW, Suite 300, [2009].

[13] N.Ganesan ,K.Venkatesh, M.Rama and A.Malathi "**Application of Neural Networks in Diagnosing Cancer Disease Using Demographic Data** ", International Journal of Computer Applications (0975 - 8887), Volume 1 – No. 26, [2010].

[14] Anil K.jain **"Fundamentals of Digital Image Processing",** Prentice Hall, Englewood Cliffs, NJ 07632 [1989].

[15] Frank y.shih "**Image Processing and Pattern Recognition Fundamentals and Techniques**", Published by John Wiley & Sons, Inc., Hoboken, New Jersey. IEEE [2010] .

[16] Torsten Seemann"**Digital Image Processing Using Local Segmentation"**, School of Computer Science and Software Engineering Faculty of Information Technology Monash University, Australia. Submission for the degree of Doctor of Philosophy, Australia [2002].

[17] Mohammed Zeki Khedher, " **Use of Neutral Network in Arabic text Translitration** ", Jordan University, 4th Conference on Recent Trends in Computer Science Applications and Information Systems[2009].

[18] Abdullah I. Al-Shoshan " **Arabic OCR Based on Image Invariants**", Proceedings of the Geometric Modeling and Imaging— New Trends (GMAI'06) 0-7695-2604-7/06 $20.00 © 2006 IEEE [2006].

[19] Somaya A. S. Al-Ma'adeed, "**Recognition of Off-line Handwritten Arabic Words**", Doctor of Philosophy Thesis, University of Nottingham, [2004].

[20] Sabri A. Mahmoud and Sameh M. Awaida "**Recognition of Offline Handwriting Arabic (indian) Numerals Using Multi Scale Featuers and Support Vector Machines VS. Hidden Markove Models**", Information and Computer Science, King Fahd University of Petroleum and Minerals Dhahran, Saudi Arabia The Arabian Journal for Science and Engineering, Volume 34, Number 2B, [2009].

[21] Roberto Gemello, Franco Mana, Dario Albesano, "**Hybrid Hmm/Neural Network Based Speech Recognition In Loquendo**", Loquendo Vocal Technology And Services,www.loquendo.com, ASR, [2006]

[22] خليل السيف ، ميسون النعيمي" **اعتماد الشبكات العصبية لتمييز جنس المتكلم"**، مجلة الرافدين لعلوم الحاسبات والرياضيات، عدد خاص بوقائع المؤتمر العلمي الثالث في تقانة المعلومات٢٩-٣٠ تشرين الثاني [٢٠١٠]

Appendix A

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

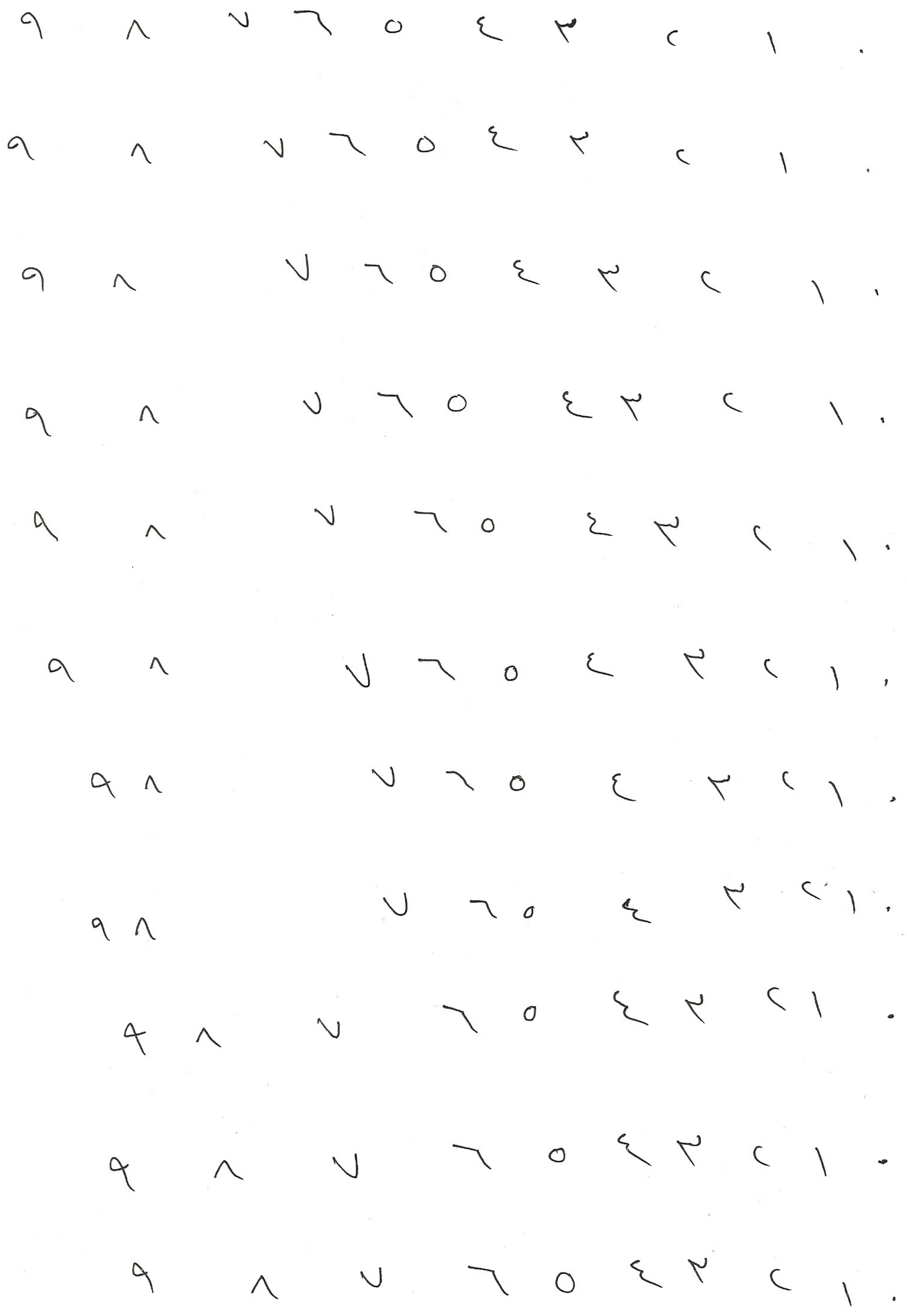
٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

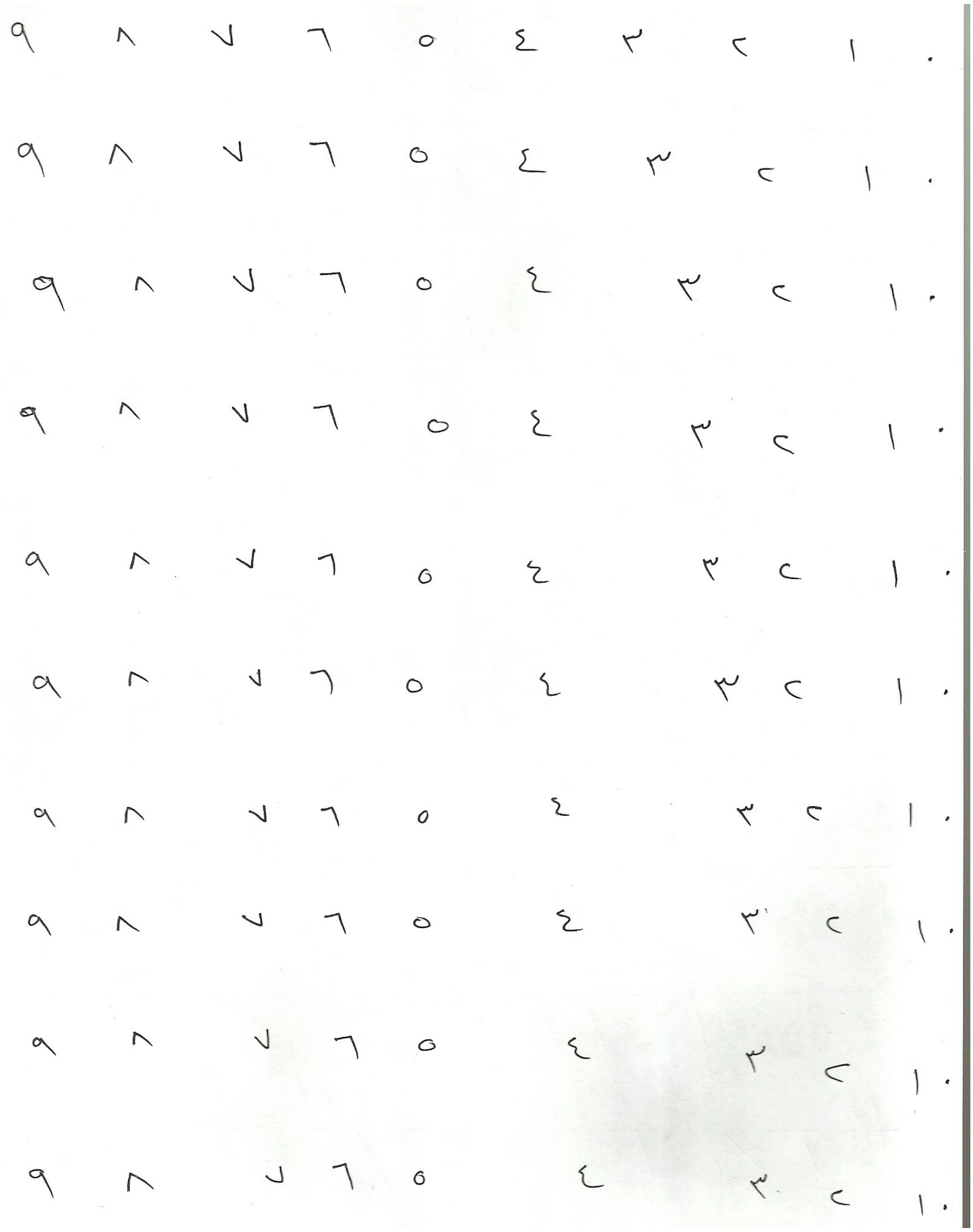
٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

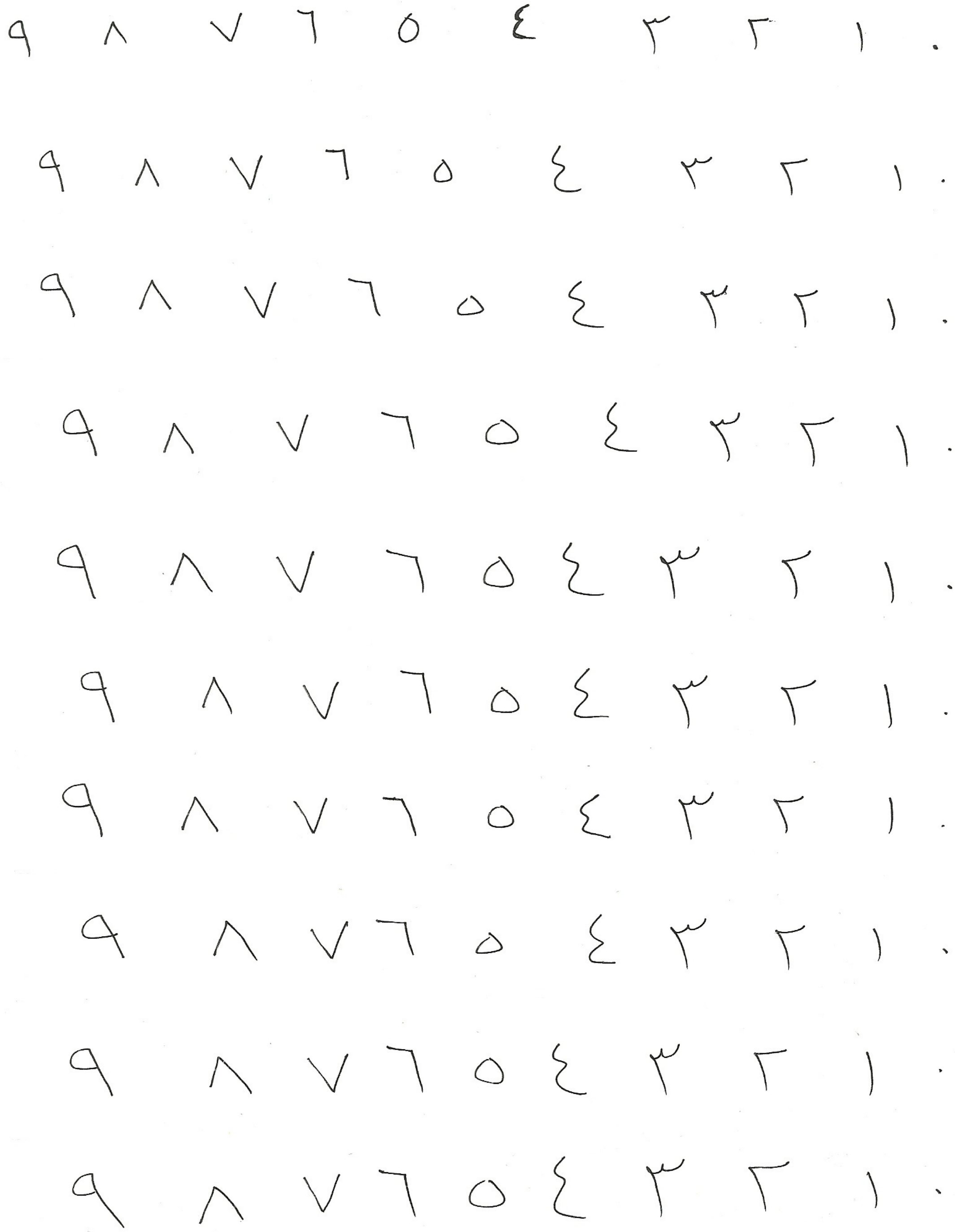
Sample 1



Sample 2



Sample 3



Sample 4

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

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٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

Sample 5

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

Sample 6

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

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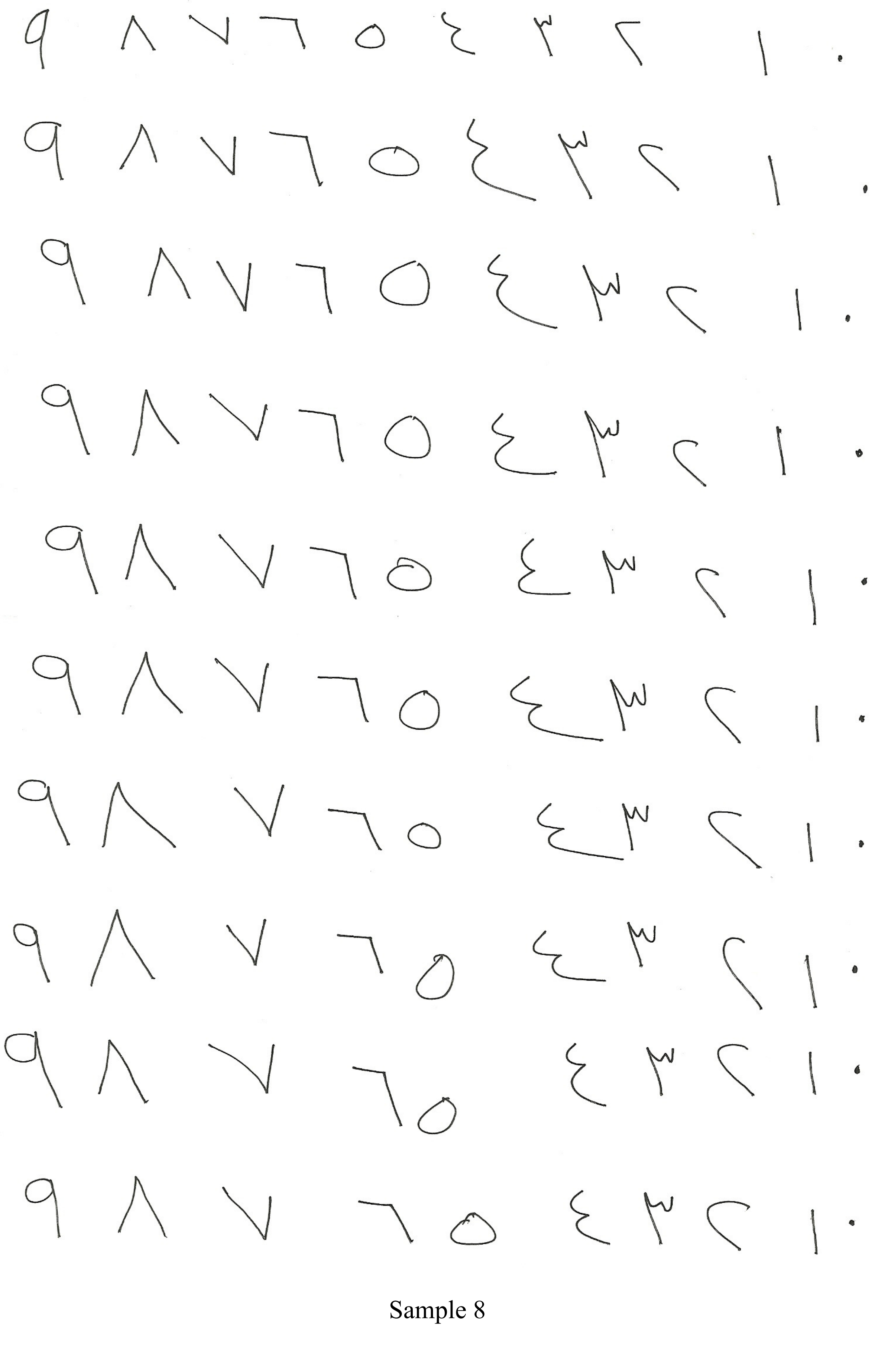
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

Sample 7


٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩
٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

Sample 8

٠ ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩

٩ ٨ ٧ ٦ ٥ ٤ ٣ ٢ ١ ٠

١ ٠ ٥ ٤ ٣ ٢ ٦ ٧ ٨ ٩

٥ ٩ ٠ ٣ ٤ ٢ ١ ٧ ٨ ٦

٦ ٧ ٨ ٩ ٠ ١ ٢ ٣ ٤ ٥

٩ ٨ ٧ ٦ ٠ ١ ٢ ٥ ٤ ٣

٣ ١ ٥ ٧ ٩ ٠ ٢ ٤ ٦ ٨

٨ ٦ ٤ ٢ ٠ ٧ ٥ ٩ ١ ٣

٥ ٠ ٦ ١ ٧ ٩ ٨ ٢ ٣ ٤

٧ ٤ ٣ ٥ ٠ ٦ ١ ٩ ٨ ٢

Sample 9

الخلاصة

تهدف هذه الدراسة لتصميم نظام قادر على تمييز الأرقام العربية (الهندية)المكتوبة بخط اليد باستخدام الشبكات العصبية والمورفولوجي الرياضية.

يستخدم هذا البحث قاعدة بيانات مؤلفه من ثلاثة عشر كاتبا مع ١٠٠ عينة لكل رقم ، بإجمالي١٣٠ عينه،تم تدريب الشبكة العصبية على مجموعه من العينات واعتبرت نماذج للمقارنة، أما بقية العينات فكانت تمثل عينات التجارب.

حققت هذه الدراسة معدلات تعرف تتراوح بين (٦٨%) إلى (٧٢.٥%) اختلفت النتائج باختلاف (Threshold) المستخدمة .

وضحت الطريقة المتبعة في هذا البحث أن الدمج بين المورفولوجي والشبكات العصبية تعطي نتائج جيده في عمليات التمييز ، ولكن بشرط أن يتم اختيار الخصائص المميزة لكل رقم بعناية، لان أهم مرحلة في هذا البحث كانت في اختيار الخصائص المناسبة، وقد استخدمت في هذا البحث مجموعه من الخصائص قابلة للتأقلم مع الصور المختلفة ، بغض النظر عن حجم تلك الصور.

تم الدمج بين الشبكات العصبية والمورفولوجي باستخدام برنامج (Matlab).